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ABSTRACT

This case study is one of a series focusing on computers as everyday learning and teaching tools which is addressed to administrators, teachers, staff, and students who wish to plan or improve the uses of computers at their own institutions. Following a brief description of the purpose and selection of cases for the overall study, the report profiles academic computing at Denison University, an independent, liberal arts college in Granville, Ohio, with 2100 full-time students. The 13-year computing history of Denison is then summarized, and the function and services of the faculty-managed computer center are described, including the use of a PDP11/45 computer for both academic and administrative purposes. Other sections report on student access to computing, costs and budgeting, student accomplishments, the spectrum of computer applications at Denison, computer literacy programs, and the computer science curriculum. Outreach programs, plans and goals, and lessons learned are also discussed. A list of contacts, a 31-item reference list, and an appendix listing the case study and exemplary institutions are included. Three figures show costs of operations, proportions of courses and faculty involved in instructional computing, and computer science course titles. (LMM)

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Academic Computing at Denison University

A Case Study

Beverly Hunter

1978
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Academic Computing at Denison University

A Case Study

Purpose

This book is one in a series of twenty-one Case Studies of Academic Computing. The Case Studies focus on the ways in which computers have come to be an everyday tool and companion to students and teachers for the purpose of learning and teaching. The Case Studies are addressed to administrators, teachers, staff and students who wish to plan, extend, or improve the uses of computers at their own institutions. You should find the Case Studies helpful in performing one or more of the following kinds of activities.

1. *Assessing the extent and nature of instructional computing at your own institution, by comparison with the Case Institutions.*

We selected a range of different sizes and kinds of institutions so that you could find one that most closely resembles your own. The Case Institutions include secondary schools, public school districts, community colleges, colleges, and universities in most regions of the continental United States.

2. *Organizing and staffing your computer center to provide improved support for instructional computing activities.*

The Case Studies highlight those aspects of organization and staffing that appear to be most significant in encouraging beneficial uses of computers for learning and teaching.

3. *Making computer resources more accessible to students.*

The Case Studies identify policies, procedures, documentation, hardware, software, and courses that facilitate student use of computing.

4. *Establishing realistic educational goals for instructional computing.*

The sections on Student Accomplishments provide ideas as to the kinds of achievements students attained with the aid of computers.

5. *Extending computer applications in particular courses and disciplines.*

Information is available in Case Books and from the contact persons listed at the back of the book concerning the kinds of computer applications used in the various academic disciplines and courses.

6. *Raising the general level of computer literacy on campus.*

The section on Computer Literacy describes goals and programs aimed at educating students and faculty regarding computer uses and the impact of computers on society.

7. *Establishing or improving a computer science curriculum.*

Most of the Case Institutions have a formal program designed to train students in computer science and/or data processing.

8. *Sharing your facilities, expertise, or curricular materials with your community or other institutions.*

The section on Outreach describes the ways the Case Institution makes an impact on the world around it with regard to instructional computing.

9. *Preparing a Five Year Plan for academic computing at your institution.*

The organization of the Case Books might be a useful framework for presenting your own Five Year Plan. Also, most of the Case Institutions have their own Plans from which you may draw ideas.

Selection of Cases

Case Institutions were selected through a four-stage procedure. First, we conducted a systematic search for institutions that are regarded as outstanding in their uses of computers for learning and teaching. Invitations were mailed to seven thousand educators and technologists who belong to professional organizations concerned with educational computing. These individuals were invited to nominate one or more educational institutions that they regard as outstanding. Nominators were asked to give specific reasons why the school should be considered, given the objectives of our study.

Over 500 individuals responded, nominating 370 institutions that met our criteria.[1] Eligible institutions included individual elementary and secondary schools, public school districts, community colleges, colleges, and universities, and public access institutions such as museums.

Second, we contacted, at each nominated institution, an individual who has a purview of instructional computing activities. In many cases, this individual is the Director of the Computing Center or a Coordinator of Instructional Computing. The nominated institutions were happy to participate, and provided information about their activities via a telephone interview with a member of our staff. The product of this stage is an Academic Computing Directory, published by HumRRO, that gives brief information on the reasons for nomination, enrollment, typical computer applications, make and model of main computer(s), number of terminals on campus, and persons to contact.

Third, the nominees were invited to respond to one or more of a series of open-ended questionnaires corresponding to the following Categories of Excellence:

1. Institutional Commitment to Instructional Computing
2. Student Accomplishments
3. Institution Productivity
4. Spectrum of Applications
5. Computer Literacy
6. Computer Science and/or Data Processing Programs
7. Outreach
8. Model

[1] Projects, consortia, timesharing companies were not eligible.

These questionnaires were quite lengthy and required considerable work on the part of the respondents. By completing one or more of the questionnaires, the respondents demonstrated their willingness and ability to share information. Over one hundred of the nominees responded in one or more categories of excellence. HumRRO staff then reviewed all candidate institutions within each Category of Excellence. We selected as Exemplars in each Category those institutions that had provided complete answers and had demonstrated a high commitment to instructional computing. Consulting experts were called upon to review candidates in specific Categories. The product of this third stage is a list of Exemplary Institutions distributed by HumRRO.[1]

Fourth, the Case Institutions were selected from among the Exemplars. The following criterion dimensions were used in selection:

1. High institution commitment to academic computing as demonstrated by the survival of instructional computing over several budget cycles; staff support for instructional computing; reform of curriculum to incorporate computer uses; increases in appropriate computing equipment; incentives to faculty for instructional innovation.
2. High degree of computer literacy among students, faculty and administration, as reflected in student accomplishments, spectrum of applications, and number of computer users on campus.
3. Appropriate response to the Model questionnaire, and usefulness of all questionnaire responses.

[1] A list of the exemplars and twenty-one Case Institutions is provided as Appendix A.

Profile

Denison is an independent, liberal arts college in Granville, Ohio. There are approximately 2100 full-time students and 142 full-time faculty members. Four degrees are offered: Bachelor of Arts, Bachelor of Science, Bachelor of Fine Arts, and Bachelor of Music. Since Denison's founding in 1831, persons of all races, creeds, national origins and sex have been eligible for admission.

Robert C. Good, President of Denison University, has described Denison and the role of computing in the following way:

The members of the faculty aspire that Denison graduates, in addition to developing their special fields of interest, cultivate respect for each of the intellectual and creative arts and a working acquaintance with each of the major fields of knowledge. In addition, we expect our graduates to master the fundamental skills and approaches to learning and to be highly motivated to use these long after graduation. To the end that our students may become self-sustained learners, we encourage them to engage in independent and directed studies and in senior research. We expect our students to know how to use a library effectively. And increasingly we also expect them to know how to use the computer.

So that Denison graduates will possess a basic understanding of the principles of modern science, three of thirteen courses required for graduation are in the natural sciences and two are in the social sciences. A course in computer science provides one option by which part of the requirement in natural science can be met. The trend is for increasing numbers of students to elect one or more courses in computing. We applaud this trend. The complexity of issues that will face our graduates obviously will require that many sectors of our society be equipped to use or to understand sophisticated computational methods.

In discharging its responsibility further to develop computer skills and to make more effective use of the computer in classroom and research work, Denison deploys three important areas of strength. First, it has been fortunate to attract one of the finest science faculties of any small college in the country. In addition, the college has made repeated financial commitments to provide necessary equipment and facilities, giving us unusual strength in science. All of the computer hardware currently in use on the campus was purchased from current income.

The second area of strength is an established record of achievement in faculty development. Fifty-seven thousand dollars per year is currently

being made available for this purpose—stipends for summer research and course improvement, attendance at workshops, the purchase of small pieces of equipment for pedagogical and research purposes, and other support. Members of the science faculty and the social science faculty have participated imaginatively in the use of these funds.

The third area of strength is work accomplished in increasing computational literacy among faculty and students. This semester substantially over one-third of our students are using the computer in courses or for research. Approximately 55 of our faculty now make use of the computer for teaching and/or research. A strong impetus in this direction has been provided by a grant from the Lilly Endowment to experiment with simulation techniques in teaching and learning. Many of the ensuing experiments made use of computer models and required increased familiarity with computer skills. The result is that the computer has already been accepted on this campus as an important tool much in the manner that the library and its many services are accepted.

The Past Thirteen Years

Significant events in the history of academic computing at Denison include the following:

1965 Establishment of Computer Center with a Burroughs 207; gift of Clevite Corporation.

1966 Lease of IBM 1130.

1968 Established (and have continuously retained) membership in The Inter-University Consortuim for Political Research (ICPR). [ECPRESS added one year later.]

1973 Purchase of PDP 11/45 [56K Memory; 2 RP03 drives; 2DH-11 (16 line) multiplexors.]
Grant from Lilly Endowment to experiment with simulation techniques.
Establishment of major program in Computer Science.

1974 Teletypewriters replaced by DECwriter II's.
COBOL added.

1975 FORTRAN, ALGOL, PASCAL, LISP, and MACRO-ASSEMBLER added.
Graphics capability acquired (for Physics Department).
Memory increased to 104K.
Local high school added as user.

1976 BASIC-PLUS-2 added.
First summer Computer Simulation Conference.

1977 Faculty Coordinator for academic computing (one-third released time) appointed to assist Director.
Three additional CRT's and remote printer added.
Second Summer Computer Simulation Conference.
Hard-wiring installed to replace acoustic couplers on all stationary terminals.

1978 Grant from National Science Foundation Comprehensive Assistance for Undergraduates Science Education (CAUSE) to increase computer uses in science instruction.

1978 (Cont.)
Third DH-11 multiplexor added.
DECAL (Version II) installed
Second "terminal room" added in classroom building (five units).
BMDP Statistics Pack added.
Faculty Coordinator becomes two-third released time, thereby doubling involvement.

— Faculty-Managed Computer Center

The computer center is managed by a Director who is a faculty member, who teaches half-time. He reports to the Dean of the College. The Director is responsible for administrative, instructional, and research applications of computing. Another faculty member reports to the Director and is responsible for coordinating all academic (non-administrative) applications.

The present management structure of the computer center has evolved to satisfy the particular requirements of the Denison environment.

The original Burroughs machine was not much more than a "toy" for academic users. It could not have been used to process administrative tasks. Consequently, the original and continuing direction of the Center was placed in the hands of a faculty member who was expected to perform all the functions necessary to oversee operations and otherwise insure that the Center was sustained. That officer reported to the Dean of the College.

With the installation of the IBM 1130, Denison had a computer able to accommodate the needs of academic users as well as the data-processing tasks required by the college administration. At that time it seemed natural to incorporate the supervision of these tasks within the Center's existing management.

Thus, all computing responsibilities were assigned to one individual who was a faculty member. A policy was established by a review committee composed of faculty and administrators which accorded academic functions the highest priority, administrative functions next, and research last. Only toward the end of the tenure of the 1130, when both administrative and academic uses increased, did this order of priorities become an issue.

Although there have been times when the Director of the Center has had to be tactful in resolving the tensions inherent in sharing the system between academic and administrative users, for the most part this arrangement has worked well. In fact, all members of the college community have been tolerant of the diversity of needs represented by those who use the single computer. As a result, Denison has a computer which, though larger than necessary for present academic uses alone, is regarded as cost-efficient resource for all concerned.

Administrative users have always had a professional staff to assist them with their data-processing problems. Until 1977, academic users have usually gone to a somewhat overworked director with their

Originally, to assist academic users, the director recruited a student corps of "programming talent," and then he served as the interface between these programmers and the faculty. As projects progressed, student programmers were able to work with faculty members more directly. This system worked well until interest in computing began to the less traditional users (e.g., faculty in English and modern languages). At this time, there is considerable interest from such non-traditional users, and they need more help to get started than is normally needed by the social and physical scientists.

In the fall of 1977, a faculty member was appointed as a one-third time "Assistant to the Director." His duties were: to work closely with academic users; to serve as a liaison between them and the Computer Center; and to stimulate their exploration of computing as a vehicle for academic instruction. This arrangement has proven so successful that the appointment has been continued and, in 1978 was increased to two-thirds time.

Faculty have been provided incentives for instructional innovation. Around $60,000 annually is spent on faculty development, largely in the form of summer stipends. Released time, financial support for attendance at workshops, and recognition in the form of "credit" towards tenure and promotion are other mechanisms for encouraging faculty development.

Student Access to Computing

The computer center's PDP 11/45 is shared for administrative and academic users. (A larger system is planned). Students use 20 CRT and typewriter terminals located in clusters in academic buildings. (More clusters are planned).

At least 50% of computer utilization is for academic, as opposed to administrative, computing. The computer center has an "open access" policy, and any student or faculty member can get an account number. Normally, all facilities are available for general use 22.5 hours each day.

In any given semester, between one-third and one-half of the students make use of computing facilities in their learning activities. On the average, each student uses approximately ten connect-hours of computer time per year.

The Five Year Plan [1] for the computer center emphasizes the mission of supporting computer literacy for all Denison students. A goal of 20 connect-hours, average per student per year, derived from Dartmouth College experience, is cited as an appropriate goal.

Costs and Budgeting

Computing has been supported by the general operating funds of the University. The approved budget of the computer center has increased every year since 1965, the year in which the computer center was established.

The costs of academic computing since 1968 are summarized in Figure 1.

Year	Instructional Expense (1)	Percent of Instructional Budget	FTE* Stud. (2)	Cost/Student Excluding Equipment	Cost/Student Including Equipment (3)	Percent of Instructional Budget Including Equipment
1977	$60,583	1.7%	2,147	$28.22	$32.88	1.9%
1976	$48,528	1.4%	2,215	$21.91	$26.42	1.7%
1975	$57,596	1.8%	2,149	$26.80	$31.45	2.1%
1974	$62,424	2.1%	2,132	$29.28	$34.02	2.4%
1973	$59,443	2.2%	2,129	$27.92		
1972	$64,912	2.5%	2,110	$30.76		
1971	$61,335	2.5%	2,153	$28.49		
1970	$62,165	2.5%	2,108	$29.49		
1969	$51,510	2.3%	2,018	$25.52		
1968	$32,551	1.6%	2,015	$16.15		

*Full-time equivalent students

(1) Instructional Expense is computed as the operating expenses of the center less those costs billed to various administrative offices. It does not include the cost of major items of equipment such as the computer itself or major additional sub-components such as disk-drives and terminals. The (approximate) total cost of the current system has been $250,000. Of this amount, approximately 50% should be attributed to instructional expense. All leasing expense, (including that associated with the main computer) as well as all maintenance expense has been included.

(2) A slight change in reporting practices for FTE students has occurred in the last several years. Although this alters the data moderately, no significant alteration in computed per-student costs would be generated by this.

(3) Since it might be somewhat unrealistic to exclude equipment costs, the cost/student was recomputed on the following basis:

a. The equivalent value of all equipment presently on-campus is estimated at $150,000.

b. The depreciation on this equipment, estimated at $100,000, has been distributed evenly over 5 years, adding equipment costs of $20,000 annually for the previous 4 years. One half of this amount ($10,000, applied at $2,500 per year) has been added to the instructional expense in order to arrive at the figure in this column.

Figure 1: **Cost of Operations of Denison Computer Center (Academic Services Only)**

Student Accomplishments

Student accomplishments attributed to computer use at Denison are illustrated in three ways: test scores and course grades; independent study and honors thesis projects; and computer programming accomplishments.

Test Scores and Course Grades

In a course in macro-economic theory, students use computer-assisted instruction lessons as substitutes for descriptive lectures. They also use simulation models which allow students to propose economic policy decisions for a hypothetical society, learn the computer-calculated results of their own decisions, and evaluate their own performance. In an experimental study, Paul King [2] found statistically significant increases in test scores and course grades between students using these computer aids and students using more traditional lecture discussion pedagogy.

Projects

Several student projects are listed as references [21] through [31] in the Reference section of this book. The following is a brief description of three projects.

Students enrolled in a course on research methods in political science cooperated in assembling large, selective data banks for analysis by the computer. Students learn how the computer may be used in conjunction with very large and otherwise unwieldy masses of data. Work done by earlier classes contributes to improvement of the course for future classes.

Frank Marinaro, a student in the Department of Mathematical Sciences, wrote a compiler to translate DYNAMO source code into the BASIC PLUS source code. The result of the project is an operating translator which provides DYNAMO to any Denison user. DYNAMO is a simple computer tool for modeling and simulation. It is useful in the sciences, social sciences and the teaching of these subjects at the undergraduate and graduate level. Marinaro's DYNAMO compiler is fully documented and has been distributed to users at several institutions [3].

Clifford Thomas, a student in the Department of Physics, constructed a mathematical model of a star from physical principles. A set of equations which determine stellar structure were derived and approximations

for the equation of state and for the physical processes of opacity and fusion were described [4].

Computer Programming

Students play an important role in the development of software and in the routine programming associated with operation of the computer center. For example, in the summers of 1974 through 1977, the Denison Computer Center employed an average of 2.5 students full time to assist in altering programs to adapt to the new computer system. During the corresponding academic years, an average of seven students a year were employed for the same purpose. Without this student help it would have been far more expensive to convert from the IBM 1130 to the PDP 11/45 computer system.

During the 1975-76 academic year, four students and two faculty constructed a software monitor to provide programmers with a measure of program performance for BASIC-PLUS programs run under the RSTS/E operating system.

Spectrum of Applications

About 55% of the departments use the computer for learning and teaching. Figure 2 shows the departments, proportion of courses, and proportion of faculty involved.

Department	Proportion of Courses	Proportion of Faculty
Biology	5%	15%
Chemistry	20%	20%
Economics	95%	100%
Education	5%	50%
English	5%	5%
Geology and Geography	10%	50%
Mathematical Sciences	50%	67%
Modern Languages	10%	15%
Philosophy	10%	20%
Physics and Astronomy	50%	25%
Political Science	15%	30%
Psychology	15%	30%
Sociology	5%	15%

Figure 2: **Proportions of Courses and Faculty Involved in Instructional Computing**

In general, about 75% of Denison students use the computer in their course work. The following are illustrative of the ways in which students use computing in the various courses, and the kinds of applications that are in development.

Biology

One biologist has been using computer simulations for instruction in molecular biology. Other departmental faculty have indicated an interest

in trying this approach in their own courses. Presently one professor is attempting to prepare DECAL lessons which will test a student's ability in medical terminology.

Chemistry

Past student use of the computer in chemistry has been restricted largely to upper level students who have either done their own programming or have used various programs for numerical analysis which have been available to them.

Computer tutorials help students to learn nomenclature in General Chemistry. In the organic laboratory, the computer generates nuclear magnetic resonance spectra artificially. Another program assists students in identifying organic compounds given as laboratory unknowns. In general chemistry, the computer has been used to administer and grade quizzes. Recently, a program written by a student as part of a January Term project has been incorporated by the department as an integral part of the study of qualitative inorganic analysis.

With more faculty expertise, existing activities will benefit more students. The increase in computer literacy will mean that more chemistry majors will be expected to do their own programming. With additional access and system diversity, there will be greater emphasis on developing programs for the large introductory courses (CAI, numerical analysis of laboratory results, and quiz administration); graphics programs for the analysis of physical chemistry topics, e.g., kinetics, wave-functions, gas behavior and molecular structure; and for developing programs in FORTRAN.

Economics

The economics department is the most advanced science department in using computing in their curriculum. Last spring every course offered by that department used computing, though some of those uses were cursory and abbreviated.

In macroeconomics, students use tutorial computer-assisted instruction lessons which substitute for descriptive lecture in macroeconomic

theory. Students also use simulation models to study economic policy decisions.

Geology and Geography

For four years this department has been attempting to implement simulations of various geological processes, such as the formation of deltas. The main obstacle to their success has been the difficulty of converting imported programs into workable form.

Mathematical Sciences

A laboratory for an elementary statistics course (200 students annually) is being developed by two Denison faculty [5]. Many of the laboratories involve the computer, either to obtain individual data, perform calculations, or to evaluate and grade numerical solutions. Sterrett and Karian [5] plan to develop additional exercises for the elementary course and to incorporate some of them into the advanced course. They also have a collection of 200 exercises in the computer from which students can obtain review problems and sample examinations. This has proven popular with the students and the procedure is likely to be adopted in other courses.

Philosophy

About 100 students annually use programs to check the syntactical accuracy of logic formulae, thereby permitting students to determine whether their formulae are logically valid.

Physics and Astronomy

This department is active in using computing in introductory courses. Students in introductory physics use computer programs to analyze raw data from their laboratory experiments. Students also use key word indices to retrieve pertinent literature references.

Computer-based physics modules for bioscience students are presently being developed by Roderick Grant of the Physics Department with the support of a National Science Foundation Local Course Improvement grant. The purpose of these modules is to assist students majoring in biosciences to be able to solve problems involving the application of physics to bioscience.

What is most needed at this point is to develop materials and techniques satisfactory for the intermediate and advanced courses. This is especially true for mechanics, electricity and magnetism, optics, and quantum physics. Additionally, the department is developing a course in digital electronics which ultimately will allow them to interface instruments with the central system.

Political Science

Students use a package of programs to analyze large data bases provided by the Intercollegiate Consortium of Political Research (ICPR). Most Denison political scientists seek expanded computer capacity for analyzing data banks. Recently there has been a move to bring simulations into the policy courses, and faculty need considerable assistance to convert imported modules into workable form.

Psychology

A simulation package currently is being used on a small scale to allow students to design sound experiments and obtain realistic data for analysis in a short time. There are many advantages to this mode of instruction, and several of these have been emphasized recently. These advantages also apply to the laboratory courses in Sensation and Perception, Cognitive Processes, and Physiological Psychology. For these courses, it is necessary to control stimulus presentation times and to obtain precise reaction data. Thus it is important that the psychology department obtain some real-time capabilities.

The same needs prevail for the course in Introductory Psychology, only magnified by the sizable number of students involved. Computer

use in this fashion would significantly reduce expenditures on other equipment needed for similar types of experiments. Due to limitations of the current computer facilities, no classes in Introductory Psychology make use of the computer.

Sociology and Anthropology

This department is introducing a statistics module into their "methods" course. They are most interested in data analysis packages, such as SPSS. They wish to have advanced students engage in model-building projects in order to study such processes as social change and social movements. There is also an interest in examining the systematic integration of multiple variables and in introducing the skills of theory-construction. The Human Relations Files (HRAF) will be used to study cross-cultural propositions. The department has been engaged in a long-term study of the local (Granville-Newark) area, and is interested in adding census figures to that bank. This will substantially aid senior research projects in the department. Finally, the department is interested in the simulation of land use development.

Spanish

Students in introductory Spanish use tutorial computer-assisted instruction programs to help them master Spanish grammar.

Computer Literacy

The goal of attaining a high level of computer literacy at Denison was adopted by both the Computer Center and administration around 1972. Robert C. Good, President of Denison University, has stated, ". . . The computer has already been accepted on this campus as an important tool much in the same manner that the library and its many services are accepted."

During the past ten years, the number of students per year who either have or seek to have computer literacy has grown from approximately 100 to 1500. Most of the growth has come about since 1974 when the PDP 11/45 system was installed. In 1974, for example, it is estimated that about 500 students per year used the computer facilities routinely. By 1976, 75% of the student body used the computer in some context during a single academic year. About 900 students have active accounts on the system each semester.

Faculty interest has also grown. In 1967, not more than ten faculty were using the system; by 1974, that number had increased to 15-20. By 1975, a fourth of the faculty had active accounts on the system.

The computer is used more extensively by students enrolled in departments where computer literacy already exists among the faculty. These are Biology, Chemistry, Economics, Education, English, Geology, Geography, Mathematical Sciences, Modern Languages, Philosophy, Physics, Astronomy, Political Science, Psychology, and Sociology.

At least 50% of Denison's students complete an Introductory Computer Science course offered by the Mathematical Sciences Department. In 1976, a January term offering was devoted to the following topics: Computer Performance and Measurement; Computer System Selection; Pros and Cons of Licensing Computer Professionals; Dynamic Memory Allocations; and Social Impact of Computers. Students write simple programs in both BASIC and in assembly language.

Student access to computing facilities is a key ingredient in achieving literacy. At Denison, all users have access to the time-sharing system 22.5 hours per day. Student and faculty accounts are issued without charge. Terminals are available in five different locations around campus.

In order to increase computing literacy at Denison, the Five Year Plan [1] calls for additional terminals, additional interactive language processors, and more staff support (notably an academic programmer) for curriculum improvement. Several faculty have indicated interest in

developing computer-augmented materials to be used in courses. Computer center support to assist faculty in these efforts is being provided through the NSF CAUSE grant.

To further increase faculty literacy, workshops are planned for the summers of 1979 and 1980. Each workshop will be four weeks long and will provide science faculty with hands-on experience in using and evaluating instructional applications in their respective disciplines.

Computer Science Curricula

Denison students have been able to concentrate in computer science since 1969, but the program for actually majoring in computer science was not established until 1973. Nine students in the 1977 graduating class graduated with a major in computer science. The number of students expected to graduate with a major in computer science in the classes of 1978 and 1979 is eleven and thirteen, respectively.

The computer science major is offered by the Department of Mathematical Sciences. Five of the mathematics faculty teach computer science courses. Occasionally the introductory course is taught by a physicist or a chemist.

Course titles for computer science courses are shown as Figure 3.

Mathematical Sciences 101—Introductory Computer Science
Mathematical Sciences 171—Introductory Computer Science (majors)
Mathematical Sciences 174—Introduction to Programming Languages
Mathematical Sciences 253—Assembly Language
Mathematical Sciences 271—Software Structure
Mathematical Sciences 272—Software Structure
Mathematical Sciences 274—Cobol and its Applications
Mathematical Sciences 331—Discrete Algebraic Structure
Mathematical Sciences 334—Automata and Formal Languages
Mathematical Sciences 346—Software Design
Mathematical Sciences 351—Differential Equations
Mathematical Sciences 352—Numerical Analysis
Mathematical Sciences 356—Mathematical Modeling and Computer Simulation
Mathematical Sciences 371—Systems Programming and Design
Mathematical Sciences 372—Systems Programming and Design
Mathematical Sciences 373—Programming Languages
Mathematical Sciences 377—Information Systems Analysis
Mathematical Sciences 382—Computer Architecture

Figure 3: **Computer Science Course Titles**

Denison's computer science majors have a number of opportunities for doing work related to their studies. Many work for the computer center directly, chiefly as programmers. Others enroll in internships or similar opportunities afforded by the January Term program; some write programs for faculty.

The following provides information on employment of graduates who concentrated their studies in computer science:

1974 Entered M.B.A. program at Carnegie-Mellon University
Programmer for Chemical Abstracts

1975 Graduate study in mathematics at Yale University
Lead Programmer for Denison University; now employed by Digital Equipment Corporation

1975 Programmer at the University of Virginia
M.B.A. program at University of Michigan
Financial management employment at General Electric Co.

1976 Graduate School of Management at Northwestern University
Programmer at Cincom Systems, Inc.
Technical Services Division of Anderson and Company

1977—First Class of Majors

Research Assistant and Computer Programmer for Nationwide Insurance
Programmer for Nationwide Insurance
Programmer for General Electric in Cleveland; working also on MBA degree
Programmer for the General Electric Credit Corporation
Systems Engineer Trainee, IBM
Computer-related employment with IBM
Lead programmer at Denison

Two 1977 graduates were seeking computer-related employment at the time of this writing.

Outreach

Denison staff, faculty and students have shared information and expertise through several mechanisms, including professional societies and interest groups; conferences; publications; hosting visitors; assistance to local high school; and distribution of programs.

Denison was instrumental in the creation of the ASCUE (Association of Small Computer Users in Education) library for PDP/11 users. In 1975, Denison founded a Local Users Group whose membership consists of all the users of PDP/11's in Ohio. In 1979, Denison will host the annual meeting of ASCUE.

Denison has exported information and programs for several computer-based learning materials. The Dynamo Compiler [3] has been described in several places and distributed to several institutions. The paper by Fletcher, *et al* [6] was presented at the 1976 Summer Computer Simulation Conference.

One of the most significant ways in which Denison extends its influence outward is through the Denison Simulation Center. Established by a grant from the Lilly Foundation, the Center serves as a repository for information related to the use of simulation in teaching and learning. In 1976 and 1977, Denison hosted a Simulation Conference on uses of computers in simulation.

Visits to Denison's computer center have been made by educators from other institutions. Recent visitors came from:

Alma College, Alma, Michigan
Ashland College, Ashland, Ohio
Central State University, Wilberforce, Ohio
Cincinnati Technical College, Cincinnati, Ohio
Edison State College, Pigua, Ohio
Grove City Community College, Grove City, Pennsylvania
Hiram College, Hiram, Ohio
Kenyon College, Gambier, Ohio
Ohio Northern University, Ada, Ohio
Ohio Wesleyan, Delaware, Ohio
Robert Morris College, Pittsburgh, Pennsylvania
Wittenberg University, Springfield, Ohio

Contacts by phone were made with:

Houghton College, Houghton, New York
Morningside College, Sioux City, Iowa
West Virginia Wesleyan University, Buckhannon, West Virginia
Wilmington College, Wilmington, Ohio

Denison provides a port to the timesharing computer for the Granville High School. In the past, Denison faculty have presented mini-courses on computing to students from eleven county high schools.

Plans and Goals

Denison Computer Center's Five Year Plan outlines the following goals:

1. Acquire the necessary equipment and personnel to support normal increases in computing volume as well as provide a reasonable increment in the quality of computing.
2. Sustain present levels of support for administrative efforts and enlarge the range of these activities.
3. Expand the consulting services offered to students and faculty, and develop the maintenance of systems resources in an effective manner.
4. Assist current faculty in developing computer skills via workshops or other mechanisms.
5. Provide access to a wider range of applications and systems software for all users.
6. Disperse computing facilities into the student living environment in order that computer use may become "natural" to their lives.
7. Support real-time processing as well as other special-purpose computing.
8. Provide limited access to remote networks, to allow faculty to explore the validity of programs available at other institutions.

In order to achieve these objectives, the following are needed:

1. A larger central computer with short turnaround time to handle more jobs simultaneously.
2. A small separate computer for real-time computing and Mathematical Sciences laboratories.
3. New clusters of terminals, and loaner terminals to encourage faculty software development.
4. Additional graphics capabilities and document reader.
5. Additional capacity for mass storage.
6. Language processors for APL, SNOBOL, and PL/1.
7. Additional applications software such as SPSS.
8. Allocation of additional space to house terminal clusters.
9. An additional programmer to support academic users.
10. Improvement in the computer literacy of faculty through summer workshops. [Optimum arrangement would be one month each summer for three summers; this plan envisions involvement by one-third of the faculty.]

Lessons Learned

In what ways might administrators from similar institutions benefit from learning about Denison's experience? Dr. Gordon Galloway, Professor of Chemistry and Assistant to the Director of the Computer Center, has this to say:

> It seems to us that administrators from other similar institutions might benefit from Denison's experience in three general ways:
>
> (a) that in the long run, the out-right purchase of computer hardware, coupled with a vigorous attempt to replace and upgrade where possible, is a good investment in the health of a college;
>
> (b) that employing student programmers and allowing them significant responsibility in the area of non-confidential administrative needs, is both prudent and economical; and
>
> (c) that continual support for faculty (for instance, in the form of summer grants, or by providing released time where possible), as they seek to improve their computer literacy, is in the best interest of the institution.

In what ways might faculty from similar institutions benefit from learning about the Denison experience?

> Perhaps the most significant way in which faculty from similar institutions may benefit from a study of our own is to become aware of the diversity and the extent of our computer operations, and to discover what steps are being taken to improve the computer-literacy of students and faculty. The computer has affected the nature and quality of education at Denison as well as the efficiency of the administrative operations.

Contacts

One way to learn from the Denison experience is to communicate directly with the Director of the Computer Center, or others who have been involved in academic computing. According to Dr. Gordon Galloway, "We would be delighted to allow others to benefit from our experience, and we welcome inquiries about our program."

The following is a list of individuals at Denison who use the computer most regularly and may be contacted regarding their academic computing activities. In addition, the individuals cited in the Documents section may also be contacted.

Name	Department
Bartlett, Dr. Robin L.	Economics
Biselow, Dr. Bruce E.	History/Simulation
Bishop, Dr. William J.	Political Science
Brisbin, Dr. Richard A. Jr.	Political Science
Buell, Dr. Emmett H.	Political Science
Burkett, Dr. Tommy R.	English
Cameron, Dr. James S.	Mathematical Sciences
Cash, Dr. Annette G.	Modern Languages (Spanish)
DeGray Dr. Ronald	Mathematical Sciences
Evans, Dr. Thomas A.	Chemistry
Fletcher, Dr. Daniel O.	Economics
Galloway, Dr. Gordon L.	Chemistry/Computer Ctr.
Gilbert, Dr. George L.	Chemistry
Grant, Dr. Roderick M.	Physics
Jalbert, Dr. Jeffery S.	Physics/Computer Ctr.
Karian, Dr. Zaven A.	Mathematical Sciences
King, Dr. Paul G.	Economics
Klatt, Dr. Kenneth P.	Biology
Larson, Dr. Lee E.	Physics
Malcuit, Dr. Robert J.	Geology/Geography
Mickelson, Dr. Michael E.	Physics
Prentice, Dr. W. Neil	Mathematical Sciences

Name	Department
Rice, Dr. Thomas J.	Sociology/Anthropology
Snyder, Dr. Rita E.	Psychology
Sterrett, Dr. Andrew	Dean of College
Straumanis, Dr. Joan	Philosophy
Thios, Dr. Samuel J.	Psychology
Toplin, Aida	Modern Languages (Spanish)
Winters, Dr. Ronald R.	Physics

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11. BARTLETT, Robin L. and AMSLER, Christine E. *A Synergistic Approach to the Decision Making Process*, Denison University.
12. BARTLETT, Robin L., and AMSLER, Christine E. *An Evaluation of the Synergistic Simulation of the Federal Open Market Committee*, Paper presented at the American Educational Research Association Meeting, April 1977.

13. CAMERON, James S. *An Approach to Benchmarking Terminal Oriented Systems*, Denison University.

14. FLETCHER, Daniel O., and BENSON, Michael. *Simulation of a Business Firm with Price Ceilings*, Denison University, May 1977.

15. KING, Paul G. *Computer Technology and the Teaching of Macroeconomics: An Evaluation.* Denison University.

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APPENDIX:

CASE STUDY AND EXEMPLAR INSTITUTIONS

Case Study

The following educational institutions have been selected to participate as Case Studies in Academic Computing.

The persons to contact regarding academic computing at the Case Study institutions are identified in the *Academic Computing Directory* published by HumRRO.

North Salem High School, Salem, Oregon
George Washington High School, Denver, Colorado
Lincoln High School, Bloomington, Minnesota
Ridgewood High School, Ridgewood, New Jersey
Riverdale Country School, Bronx, New York
Huntington Beach Union High School District, Huntington Beach, California
Alexis I. DuPont School District, Greenville, Delaware
Chicago Public Schools, Chicago, Illinois
Dallas Independent School District, Dallas, Texas
Lawrence Hall of Science, Berkeley, California
William Rainey Harper Community College, Palatine, Illinois
Golden West Community College, Huntington Beach, California
United States Naval Academy, Annapolis, Maryland
Worcester Polytechnic Institute, Worcester, Massachusetts
Denison University, Granville, Ohio
Evergreen State College, Olympia, Washington
Jackson State University, Jackson, Mississippi
Mankato State University, Mankato, Minnesota
Rutgers, The State University, Piscataway, New Jersey
University of Delaware, Newark, Delaware
University of Texas, Austin, Texas

Exemplar Institutions

Educational institutions identified here are participating in the study, "Exemplary Institutions in Academic Computing." These institutions have been selected as Exemplars in one or more Categories of Excellence, on the basis of written responses to a series of questionnaires prepared by the Human Resources Research Organization.

Individuals to contact regarding academic computing at the Exemplar institutions, may be found in the *Academic Computing Directory* published by HumRRO.

CATEGORY 1: STUDENT ACCOMPLISHMENTS

Colleges and Universities With Student Enrollment Over 6,000 FTE

University of California, Irvine (CA)
University of Akron (OH)
University of Pittsburgh (PA)
University of Texas, Austin (TX)

Colleges and Universities With Student Enrollment Under 6,000 FTE

University of D.C., Van Ness
Grinnell College (IO)
Transylvania University (KY)
U.S. Naval Academy (MD)
Worcester Polytechnic Institute (MA)
Bennett College (NC)
Denison University (OH)
Evergreen State College (WA)

Community Colleges

Gavilan College (CA)
Golden West College (CA)
William Rainey Harper College (IL)
Burlington County College (NJ)

Elementary and Secondary Schools

George Washington HS (CO)
Ballou HS (DC)
Hull HS (MA)
Joyner Elementary School (NC)
Amherst Central Senior HS (NY)
Riverdale Country School (NY)
Belmont HS (OH)
North Salem HS (OR)
Sehome HS (WA)

Public School Districts

Huntington Beach USD (CA)
Los Nietos ESD (CA)
Montgomery County PS (MD)
School District of Kansas City (MO)
Syosset Central SD (NY)
Woodridge PS (OH)
Memphis City Schools (TN)
Dallas ISD (TX)
Richardson ISD (TX)
Jordan SD (UT)
Fairfax PS (VA)
Highline SD (WA)

Public Access

Capital Area Career Center (MI)

CATEGORY 2: INSTITUTION ACCOMPLISHMENTS

Colleges and Universities With Student Enrollment Over 6,000 FTE

New York Institute of Technology (NY)
University of Pittsburgh (PA)
University of Texas, Austin (TX)

Colleges and Universities With Student Enrollment Under 6,000 FTE

Trinity College (CT)
University of Tennessee, Chattanooga (TN)
Trinity University (TX)
Carnegie-Mellon (PA)

Community Colleges

Golden West College (CA)

Elementary and Secondary Schools

Ballou HS (DC)
Garden City HS (KS)
Lincoln HS (MN)

Public School Districts

Huntington Beach USD (CA)
Atlanta PS (GA)
Chicago PS (IL)
Albuquerque PS (NM)
Jamesville-DeWitt CSD (NY)

CATEGORY 3: SPECTRUM OF COMPUTER APPLICATIONS TO LEARNING AND TEACHING

Colleges and Universities with Student Enrollment Over 6,000 FTE

Auburn University (AL)
California State at Fresno (CA)
Stanford University (CA)
University of Colorado, Boulder (CO)
University of Delaware (DE)
Southern University and A&M College (LA)
Mankato State University (MN)
Rutgers University (NJ)
Ohio State University (OH)
University of Pittsburgh (PA)
University of Texas, Austin (TX)
University of Texas, El Paso (TX)
Western Washington University (WA)
University of Wisconsin, LaCrosse (WI)

Colleges and Universities With Student Enrollment Under 6,000 FTE

Colorado School of Mines (CO)
Fairfield University (CT)
Trinity College (CT)
Anderson College (IN)
Grinnell College (IO)
Emporia State University (KS)
U.S. Naval Academy (MD)
Carleton College (MN)
Northern Montana College (MT)
Worcester Polytechnic Institute (MA)
Dartmouth College (NH)
Hamilton/Kirkland College (NY)
Bennett College (NC)
University of North Carolina, Asheville (NC)
Denison University (OH)
Bucknell University (PA)
University of Tennessee, Chattanooga (TN)
University of Tennessee, Martin (TN)
Trinity University (TX)
Evergreen State College (WA)
University Wisconsin, Superior (WI)

Community Colleges

Golden West College (CA)
William Rainey Harper College (IL)
St. Louis CC, Florissant Valley (MO)
Broome County CC (NY)
Roane State CC (TN)

Elementary and Secondary Schools

George Washington HS (CO)
Garden City HS (KS)
Lincoln HS (MN)
Maple Lake HS (MN)
Ridgewood HS (NJ)
Teaneck HS (NJ)
Commack HS South (NY)
Jericho HS (NY)
Joyner Elementary School (NC)
West Cary Jr. HS (NC)
Belmont HS (OH)
Catlin Gabel School (OR)

Public School Districts

Huntington Beach USD (CA)
Palo Alto SD (CA)
San Francisco Unified SD (CA)
Chicago Public Schools (IL)
Wichita PS (KS)
Jamesville-DeWitt CSD (NY)
Dallas ISD (TX)

CATEGORY 4: COMPUTER LITERACY PROGRAMS FOR STUDENTS, FACULTY OR COMMUNITY

Colleges and Universities With Student Enrollment Over 6,000 FTE

Auburn University (AL)
University of California, San Diego (CA)
Mankato State University (MN)
Rutgers University (NJ)
University of Illinois, Urbana (IL)
New York Institute of Technology (NY)
University of Texas, Austin (TX)
University of Texas, El Paso (TX)
University of Wisconsin, LaCrosse (WI)

Colleges and Universities With Student Enrollment Under 6,000 FTE

Colorado School of Mines (CO)
Fairfield University (CT)
Grinnell College (IO)
U.S. Naval Academy (MD)
Carleton College (MN)
Northern Montana College (MT)
Dartmouth College (NH)
Bennett College (NC)
Denison University (OH)
Cameron University (OK)
Bucknell University (PA)
Moravian College (PA)
University of Tennessee, Chattanooga (TN)
Trinity University (TX)
Evergreen State College (WA)

Community Colleges

Gavilan College (CA)
Mercer County CC (NJ)

Elementary and Secondary Schools

George Washington HS (CO)
St. Patrick HS (IL)
Lincoln HS (MN)
Maple Lake HS (MN)
North Salem HS (OR)
Teaneck HS (NJ)
Amherst Central Senior HS (NY)
Riverdale Country School (NY)

Public School Districts

Huntington Beach USD (CA)
Palo Alto USD (CA)
San Jose USD (CA)
Alexis I. DuPont (DE)
Montgomery County PS (MD)
Albuquerque PS (NM)
N. Syracuse Central SD (NY)
Dallas ISD (TX)
Richardson ISD (TX)
Fairfax County PS (VA)
Highline SD (WA)

Public Access

Lawrence Hall of Science (CA)

CATEGORY 5: COMPUTER SCIENCE OR DATA PROCESSING CURRICULA

Colleges and Universities With Student Enrollment Over 6,000 FTE

California Polytechnic State University, San Luis Obispo (CA)
Mankato State University (MN)
Western Washington University (WA)
University of Colorado, Boulder (CO)
Rutgers University (NJ)
Ohio State University (OH)
University of Texas, Austin (TX)
University of Wisconsin, LaCrosse (WI)

Colleges and Universities With Student Enrollment Under 6,000 FTE

Anderson College (IN)
U.S. Naval Academy (MD)
Worcester Polytechnic Institute (MA)
University of North Carolina, Wilmington (NC)
State University of New York, Plattsburgh (NY)
Bucknell University (PA)
Carnegie-Mellon (PA)

Community Colleges

William Rainey Harper College (IL)
St. Louis Community College, Florissant Valley (MO)
Burlington County College (NJ)
Mercer County College (NJ)
Roane State Community College (TN)

Elementary and Secondary Schools

George Washington HS (CO)
Ballou HS (DC)
Hull HS (MA)
Belmont HS (OH)
N. Salem HS (OR)
Ridgewood HS (NJ)
Teaneck HS (NJ)
Amsterdam HS (NY)
Commack HS South (NY)
Riverdale Country School (NY)
Sehome HS (WA)

Public School Districts

Jefferson County PS (CO)
Alexis I. DuPont SD (DE)
Atlanta PS (GA)
Chicago PS (IL)
Albuquerque PS (NM)
Churchill Area SD (PA)
Dallas ISD (TX)
Fairfax County PS (VA)

CATEGORY 6: OUTREACH TO COMMUNITY AND OTHER INSTITUTIONS

Colleges and Universities With Student Enrollment Over 6,000 FTE

California State, Fresno (CA)
University of California, Irvine (CA)
University of Illinois, Urbana (IL)
Mankato State University (MN)
Jackson State University (MS)
University of North Dakota (ND)
University of Akron (OH)
Ohio State University (OH)
University of Pittsburgh (PA)
University of Texas, Austin (TX)
Western Washington University (WA)
University of Wisconsin, LaCrosse (WI)

Colleges and Universities With Student Enrollment Under 6,000 FTE

Fairfield University (CT)
Lewis University (IL)
Grinnell College (IO)
U.S. Naval Academy (MD)
Worcester Polytechnic Institute (MA)
Northern Montana College (MT)
Dartmouth College (NH)
University of North Carolina, Asheville (NC)
Denison University (OH)
Bucknell University (PA)
University of Tennessee, Chattanooga (TN)
Rice University (TX)
Evergreen State College (WA)

Community Colleges

Maricopa Community College District (AZ)
Gavilan College (CA)
Golden West College (CA)
Burlington County College (NJ)
Mercer County Community College (NJ)
Roane State Community College (TN)

Elementary and Secondary Schools

George Washington HS (CO)
Canterbury School (CT)
Ballou HS (DC)
St. Patrick HS (IL)
Hull HS (MA)
Ridgewood HS (NJ)
Riverdale Country School (NY)
Belmont HS (OH)
Catlin Gabel (OR)
Upper St. Clair HS (PA)
Sehome HS (WA)

Public School Districts

Huntington Beach USD (CA)
Los Nietos ESD (CA)
San Francisco Unified SD (CA)
Jefferson County PS (CO)
Alexia I. DuPont SD (DE)
School District of Kansas City (MO)
Wayne Township PSD (NJ)
Jamesville-DeWitt CSD (NY)
Churchill Area SD (PA)
Dallas ISD (TX)
Fairfax County PS (VA)

Public Access

Lawrence Hall of Science (CA)
Capital Area Career Center (MI)

Foreword

This book was prepared by the Human Resources Research Organization and supported by the National Science Foundation Science Education Directorate, Grant Number SED-76-15399. Dr. Robert J. Seidel, Director of HumRRO's Eastern Division in Alexandria, Virginia, is Principal Investigator for the project, and Ms. Beverly Hunter is co-Principal Investigator. Any opinions, findings, and conclusions or recommendations expressed in this book are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Dr. Gordon Galloway, Professor of Chemistry and Assistant Director of the Denison Computer Center, gathered the information on Denison's academic computing that is described in this book.